

Practitioner's Docket No. 64631-0020

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application  
Assistant Commissioner for Patents  
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of  
Inventor(s): **Steven M. Shepard**

**WARNING:** 37 C.F.R. § 1.41(a)(1) points out:

*"(a) A patent is applied for in the name or names of the actual inventor or inventors.*

*(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(i) is filed supplying or changing the name or names of the inventor or inventors."*

For (title): **Method and Apparatus for Detecting Kissing Unbond Defects**

**CERTIFICATION UNDER 37 C.F.R. 1.10\***

*(Express Mail label number is mandatory.)*

*(Express Mail certification is optional.)*

I hereby certify that this correspondence and the documents referred to as attached therein are being deposited with the United States Postal Service on this date 12/02/99, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number **EL429913725US**, addressed to the: Box Patent Application, Assistant Commissioner for Patents, Washington, D.C. 20231.

Joyce Krumpe

*(type or print name of person mailing paper)*

Joyce Krumpe  
Signature of person mailing paper

**WARNING:**

*Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.*

**\*WARNING:**

*Each paper or fee filed by "Express Mail" must have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. 1.10(b).*

*"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will not be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

## 1. Type of Application

This new application is for a(n)

(check one applicable item below)

- ☒ Original (nonprovisional)  
☐ Design  
☐ Plant

**WARNING:** Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. 371(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.

**WARNING:** Do not use this transmittal for the filing of a provisional application.

**NOTE:** If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.

- ☐ Divisional.  
☐ Continuation.  
☐ Continuation-in-part (C-I-P).

## 2. Benefit of Prior U.S. Application(s) (35 U.S.C. 119(e), 120, or 121)

**NOTE:** A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. 112. Each prior application must also be:

- (i) An international application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America, or
- (ii) Complete as set forth in § 1.51(b), or
- (iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or
- (iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(f) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

**NOTE** If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

**WARNING:** If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. 120, 121 or 365(c). (35 U.S.C. 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

**WARNING:** When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within



☒ The new application being transmitted claims the benefit of prior U.S. application(s).  
Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE  
BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

**3. Papers Enclosed**

**A. Required for Filing Date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application**

10 Pages of Specification

6 Pages of Claims

8 Sheets of Drawing

☐ Formal  
☒ Informal

**WARNING:** *DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).*

**NOTE:** *"Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (5/8 inch) down from the top of the page. . . " 37 C.F.R. § 1.84(c)).*

*(complete the following, if applicable)*

☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).

**B. Other Papers Enclosed**

\_\_\_\_\_ Pages of declaration and power of attorney

1 Pages of Abstract

\_\_\_\_\_ Other

#### 4. Additional Papers Enclosed

- ☐ Amendment to claims
- ☐ Cancel in this applications claims \_\_\_\_\_ before calculating the filing fee.  
(At least one original independent claim must be retained for filing purposes.)
- ☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)
- ☐ Preliminary Amendment
- ☐ Information Disclosure Statement (37 C.F.R. § 1.98)
- ☐ Form PTO-1449 (PTO/SB/08A and 08B)
- ☐ Citations
- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

#### 5. Declaration or Oath (including power of attorney)

**NOTE:** A newly executed declaration is not required in a continuation or divisional application provided the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47 then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. § 1.63(d)(1)-(3).

**NOTE:** A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name, including the family name, and at least one given name without abbreviation together with any other given name or initial, and the residence, post office address and country of citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).

- ☐ Enclosed  
Executed by

(check all applicable boxes)

- ☐ inventor(s).
- ☐ legal representative of inventor(s). 37 C.F.R. § 1.42 or 1.43.
- ☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.
- ☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F.R. § 1.47 is also attached. See item 13 below for fee.

- ☒ Not Enclosed.

**NOTE:** Where the filing is a completion in the U.S. of an International Application, or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

- ☐ Application is made by a person authorized under 37 C.F.R. 1.41(c) on behalf of *all* the above named inventor(s).

*(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e), can be filed subsequently).*

- ☐ Showing that the filing is authorized.  
*(not required unless called into question. 37 C.F.R. § 1.41(d))*

## 6. Inventorship Statement

**WARNING:** *If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.*

The inventorship for all the claims in this application are:

- ☒ The same.
- or
- ☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,
- ☐ is submitted.
- ☐ will be submitted.

## 7. Language

**NOTE:** *An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of \$130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).*

- ☒ English
- ☐ Non-English
- ☐ The attached translation includes a statement that the translation is accurate.  
37 C.F.R. § 1.52(d).

## 8. Assignment

- ☐ An assignment of the invention to
- ☐ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or [ ] FORM PTO 1595 is also attached.
- ☐ will follow.

**NOTE:** *"If an assignment is submitted with a new application, send two separate letters-one for the application and one for the assignment" Notice of May 4, 1990 (1114 O.G. 77-78).*

**WARNING:** *A newly executed "STATEMENT UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.*

## 9. Certified Copy

Certified copy(ies) of application(s)

country	appln. no.	filed
country	appln. no.	filed
country	appln. no.	filed

from which priority is claimed

- ☐ is (are) attached.  
☐ will follow.

**NOTE.** The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.

**NOTE.** This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

## 10. Fee Calculation (37 C.F.R. § 1.16)

A. ☒ Regular application

CLAIMS AS FILED			
Number Filed	Number Extra	Rate	Basic Fee 37 CFR 1.16(a) \$ 760.00
Total Claims (37 CFR 1.16(c))	28 - 20 = 8	X \$ 18.00	144.00
Independent Claims (37 CFR 1.16(b))	3 - 3 =	X \$ 78.00	
Multiple dependent claims, if any, (37 CFR 1.16(d))		X \$ 260.00	

- ☐ Amendment cancelling extra claims is enclosed.  
☐ Amendment deleting multiple-dependencies is enclosed.  
☐ Fee for extra claims is not being paid at this time.

**NOTE:** If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(d).

Filing Fee Calculation \$ 904.00

- B. ☐ Design application  
(\$310.00—37 C.F.R. § 1.16(f))

Filing Fee Calculation \$ \_\_\_\_\_

- C. ☐ Plant application  
(\$480.00—37 C.F.R. § 1.16(g))

Filing Fee Calculation \$ \_\_\_\_\_

**11. Small Entity Statement(s)**

- ☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. §§ 1.9 and 1.27 is (are) attached.

**WARNING:** "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2)

(complete the following, if applicable)

- ☒ Status as a small entity was claimed in prior application 60/128,931  
filed on 4/6/99 from which benefit is being claimed for this application under:

35 U.S.C. § ☒ 119(e),  
☐ 120,  
☐ 121,  
☐ 365(c),

and which status as a small entity is still proper and desired.

- ☒ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of A, B or C above) \$ 452.00

**NOTE:** Any excess of the full fee paid will be refunded if a small entity status is established refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 C.F.R. § 1.28(a).

**12. Request for International-Type Search (37 C.F.R. § 1.104(d))**

(complete, if applicable)

- ☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.



13. Fee Payment Being Made at This Time

☒ Not Enclosed

☒ No filing fee is to be paid at this time.  
(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)

☐ Enclosed

☐ Filing fee \$ \_\_\_\_\_

☐ Recording assignment  
(\$40.00; 37 C.F.R. § 1.21(h))  
(See attached "COVER SHEET FOR  
ASSIGNMENT ACCOMPANYING NEW  
APPLICATION.") \$ \_\_\_\_\_

☐ Petition fee for filing by other  
than all the inventors or person  
on behalf of the inventor where  
inventor refused to sign or cannot  
be reached  
(\$130.00; 37 C.F.R. §§ 1.47 and 1.17(i)) \$ \_\_\_\_\_

☐ For processing an application with a  
specification in a non-English language  
(\$130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k)) \$ \_\_\_\_\_

☐ Processing and retention fee  
(\$130.00; 37 C.F.R. §§ 1.53(d) and 1.21(l)) \$ \_\_\_\_\_

☐ Fee for international-type search report  
(\$40.00; 37 C.F.R. § 1.21(e)) \$ \_\_\_\_\_

NOTE 37 C.F.R. § 1.21(l) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. § 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from notification under § 53(f).

Total Fees Enclosed \$ \_\_\_\_\_

14. Method of Payment of Fees

☐ Check in the amount of \$ \_\_\_\_\_.

☐ Charge Account No. **18-0013** in the amount of \$ \_\_\_\_\_.  
A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 C.F.R. § 1.22(b).

## 15. Authorization to Charge Additional Fees

**WARNING:** If no fees are to be paid on filing, the following items should not be completed.

**WARNING:** Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.

☐ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. **18-0013**.

☐ 37 C.F.R. § 1.16(a), (f) or (g) (filing fees)

☐ 37 C.F.R. § 1.16(b), (c) and (d) (presentation of extra claims)

**NOTE:** Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

☐ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☐ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a).

☒ 37 C.F.R. § 1.17 (application processing fees)

**NOTE:** "A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

**NOTE:** Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b)).

**NOTE:** 37 C.F.R. § 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . issue fee." From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

**16. Instructions as to Overpayment**

NOTE: "... Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

☒ Credit Account No. **18-0013**.

☐ Refund.

Date: December 2, 1999

Reg. No. 33373

Tel. No.: (248) 594-0650

Customer No. 010291

  
**SIGNATURE OF PRACTITIONER**

Joseph V. Coppola, Sr.

RADER, FISHMAN & GRAUER PLLC

1533 North Woodward Avenue,

Suite 140

Bloomfield Hills, Michigan 48304

☒ **Incorporation by reference of added pages**

*(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)*

☒ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added 5

☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added \_\_\_\_\_

☐ Plus added pages deleting names of inventor(s) named on prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added \_\_\_\_\_

☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added \_\_\_\_\_

**Statement Where No Further Pages Added**

*(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)*

This transmittal ends with this page.

# **ADDED PAGES FOR APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED**

NOTE: See 37 C.F.R. § 1.78.

## **17. Relate Back**

**WARNING:** *If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. 120, 121 or 365(c). (35 U.S.C. 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.*

*(complete the following, if applicable)*

☒ Amend the specification by inserting, before the first line, the following sentence:

### **A. 35 U.S.C. 119(e)**

NOTE: *"Any nonprovisional application claiming the benefit of one or more prior filed copending provisional applications must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior provisional application, identifying it as a provisional application, and including the provisional application number (consisting of series code and serial number)." 37 C.F.R. § 1.78(a)(4).*

☒ "This application claims the benefit of U.S. Provisional Application(s) No(s).:

**APPLICATION NO(S).:**

**FILING DATE**

**60/128,031**

**04/06/99**

### **B. 35 U.S.C. 120, 121 and 365(c)**

NOTE: *"Except for a continued prosecution application filed under § 1.53(d), any nonprovisional application claiming the benefit of one or more prior filed copending nonprovisional applications or international applications designating the United States of America must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior application, identifying it by application number (consisting of the series code and serial number) or international application number and international filing date and indicating the relationship of the applications. . . . Cross-references to other related applications may be made when appropriate." (See § 1.14(a)). 37 C.F.R. § 1.78(a)(2).*

- ☐ "This application is a
- ☐ continuation
- ☐ continuation-in-part
- ☐ divisional

of copending application(s)

- ☐ application number \_\_\_\_\_ filed on \_\_\_\_\_"
- ☐ International Application \_\_\_\_\_ filed on \_\_\_\_\_ and which designated the U.S."

NOTE: The proper reference to a prior filed PCT application that entered the U.S. national phase is the U.S. serial number and the filing date of the PCT application that designated the U.S.

NOTE: (1) Where the application being transmitted adds subject matter to the International Application, then the filing can be as a continuation-in-part or (2) if it is desired to do so for other reasons then the filing can be as a continuation.

NOTE: The deadline for entering the national phase in the U.S. for an international application was clarified in the Notice of April 28, 1987 (1079 O.G. 32 to 46) as follows:

"The Patent and Trademark Office considers the International application to be pending until the 22nd month from the priority date if the United States has been designated and no Demand for International Preliminary Examination has been filed prior to the expiration of the 19th month from the priority date and until the 32nd month from the priority date if a Demand for International Preliminary Examination which elected the United States of America has been filed prior to the expiration of the 19th month from the priority date, provided that a copy of the international application has been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively. If a copy of the international application has not been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively, the international application becomes abandoned as to the United States 20 or 30 months from the priority date respectively. These periods have been placed in the rules as paragraph (h) of § 1.494 and paragraph (i) of § 1.495. A continuing application under 35 U.S.C. 365(c) and 120 may be filed anytime during the pendency of the international application."

- ☐ "The nonprovisional application designated above, namely application \_\_\_\_\_, filed \_\_\_\_\_, claims the benefit of U.S. Provisional Application(s) No(s):

**APPLICATION NO(S):**

**FILING DATE**

- ☐ Where more than one reference is made above please combine all references into one sentence.

## 18. Relate Back—35 U.S.C. 119 Priority Claim for Prior Application

The prior U.S. application(s), including any prior International Application designating the U.S., identified above in item 17B, in turn itself claim(s) foreign priority(ies) as follows:

Country	Appln. no.	Filed
---------	------------	-------

The certified copy(ies) has (have)

☐ been filed on \_\_\_\_\_, in prior application \_\_\_\_\_, which was filed on \_\_\_\_\_.

☐ is (are) attached.

**WARNING:** *The certified copy of the priority application that may have been communicated to the PTO by the International Bureau may not be relied on without any need to file a certified copy of the priority application in the continuing application. This is so because the certified copy of the priority application communicated by the International Bureau is placed in a folder and is not assigned a U.S. serial number unless the national stage is entered. Such folders are disposed of if the national stage is not entered. Therefore, such certified copies may not be available if needed later in the prosecution of a continuing application. An alternative would be to physically remove the priority documents from the folders and transfer them to the continuing application. The resources required to request transfer, retrieve the folders, make suitable record notations, transfer the certified copies, enter and make a record of such copies in the Continuing Application are substantial. Accordingly, the priority documents in folders of international applications that have not entered the national stage may not be relied on. Notice of April 28, 1987 (1079 O.G. 32 to 46).*

## 19. Maintenance of Copendency of Prior Application

**NOTE.** *The PTO finds it useful if a copy of the petition filed in the prior application extending the term for response is filed with the papers constituting the filing of the continuation application. Notice of November 5, 1985 (1060 O.G. 27)*

A. ☐ Extension of time in prior application

*(This item **must** be completed and the papers filed in the prior application, if the period set in the prior application has run.)*

☐ A petition, fee and response extends the term in the pending **prior** application until \_\_\_\_\_

☐ A **copy** of the petition filed in prior application is attached.

B. ☐ Conditional Petition for Extension of Time in Prior Application

*(complete this item, if previous item not applicable)*

☐ A conditional petition for extension of time is being filed in the pending **prior** application.

☐ A **copy** of the conditional petition filed in the prior application is attached.

**20. Further Inventorship Statement Where Benefit of Prior Application(s) Claimed**

*(complete applicable item (a), (b) and/or (c) below)*

- (a) ☒ This application discloses and claims only subject matter disclosed in the prior application whose particulars are set out above and the inventor(s) in this application are

☒ the same.

☐ less than those named in the prior application. It is requested that the following inventor(s) identified for the prior application be deleted:

---

*(type name(s) of inventor(s) to be deleted)*

- (b) ☐ This application discloses and claims additional disclosure by amendment and a new declaration or oath is being filed. With respect to the prior application, the inventor(s) in this application are

☐ the same.

☐ the following additional inventor(s) have been added:

---

*(type name(s) of inventor(s) to be deleted)*

- (c) ☒ The inventorship for all the claims in this application are

☒ the same.

☐ not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made

☐ is submitted.

☐ will be submitted.

**21. Abandonment of Prior Application (if applicable)**

- ☐ Please abandon the prior application at a time while the prior application is pending, or when the petition for extension of time or to revive in that application is granted, and when this application is granted a filing date, so as to make this application copending with said prior application.

**NOTE:** According to the Notice of May 13, 1983 (103, TMOG 6-7), the filing of a continuation or continuation-in-part application is a proper response with respect to a petition for extension of time or a petition to revive and should include the express abandonment of the prior application conditioned upon the granting of the petition and the granting of a filing date to the continuing application.

## 22. Petition for Suspension of Prosecution for the Time Necessary to File an Amendment

**WARNING:** "The claims of a new application may be finally rejected in the first Office action in those situations where (1) the new application is a continuing application of, or a substitute for, an earlier application, and (2) all the claims of the new application (a) are drawn to the same invention claimed in the earlier application, and (b) would have been properly finally rejected on the grounds of art of record in the next Office action if they had been entered in the earlier application." MPEP, § 706.07(b), 6th ed., rev.2 ☐

**NOTE:** Where it is possible that the claims on file will give rise to a first action final for this continuation application and for some reason an amendment cannot be filed promptly (e.g., experimental data is being gathered) it may be desirable to file a petition for suspension of prosecution for the time necessary.

(check the next item, if applicable)

- ☐ There is provided herewith a Petition To Suspend Prosecution for the Time Necessary to File An Amendment (New Application Filed Concurrently)

## 23. Small Entity (37 CFR § 1.28(a))

- ☒ Applicant has established small entity status by the filing of a statement in parent application 60/128,031 on 04/06/99.

- ☒ A copy of the statement previously filed is included.

**WARNING:** See 37 CFR § 1.28(a).

## 24. NOTIFICATION IN PARENT APPLICATION OF THIS FILING

- ☐ A notification of the filing of this  
(check one of the following)

- ☐ continuation  
☐ continuation-in-part  
☐ divisional

is being filed in the parent application, from which this application claims priority under 35 U.S.C. § 120.



**VERIFIED STATEMENT BY ASSIGNEE CLAIMING  
SMALL ENTITY STATUS (37 C.F.R. 1.9(f) and 1.27(c))  
(Small Business Concern)**

I hereby declare that I am an official of Thermal Wave Imaging, Inc. and am empowered to act on its behalf.

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled:

**METHOD AND APPARATUS FOR DETECTION OF  
KISSING UNBOND DEFECTS**

by inventor(s) Steven M. Shepard as described in the application filed April 6, 1999, U.S. Serial No. 60/128,031.

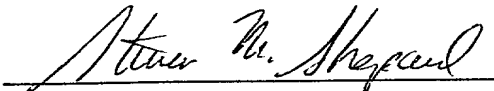
If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under CFR 1.9(e): None

I acknowledge the duty to file, in this application or patent, notification of any change in status result in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

64631-019

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent to which this verified statement is directed.

Dated: 4/15/99

  
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R0051887

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UNITED STATES PATENT APPLICATION

of

**STEVEN M. SHEPARD**

a citizen of USA  
residing at 23656 Hunter's Lane  
Southfield MI 48034

for new and useful invention entitled:

**METHOD AND APPARATUS FOR DETECTING KISSING UNBOND DEFECTS**

Joseph V. Coppola, Sr., Reg. No. 33,373  
Anna M. Shih, Reg. No. 36,372  
Attorney Docket No. 64631-0020

**METHOD AND APPARATUS FOR  
DETECTING KISSING UNBOND DEFECTS**

TECHNICAL FIELD

5           The present invention is directed to a method and apparatus for detecting subsurface defects in a specimen, and more particularly to a method and apparatus for detecting kissing unbond defects.

BACKGROUND ART

10           Active thermographic methods are often used to detect subsurface defects in a test specimen; that is, defects that are not readily ascertainable by viewing the specimen's surface. Active thermographic methods are often preferred because they are non-destructive and because they are capable of quickly locating subsurface defects over a large surface area. These methods usually involve heating the surface of the specimen  
15           and monitoring the subsequent heat signature radiated over a period of time from the specimen by way of an infrared camera. Subsurface air gaps or vacuums within the tested specimen are good thermal insulators when compared with the surrounding material and will therefore appear as a high-contrast thermal discontinuity in the thermographic image sequence due to the differences in heat flow between the defect and the surrounding  
20           defect-free area.

          In some cases, however, the subsurface defect does not appear clearly in the thermographic image sequence because the walls of the defect are in mechanical contact, allowing at least some heat flow across the defect. This type of defect is often called a "kissing unbond" defect and is illustrated in Figure 1A. As can be seen in Figure 1A, the  
25           upper 106 and lower 108 walls of the defect 100 touch each other. Conventional active

thermographic methods often cannot detect this type of defect because the mechanical contact between the walls of the defect provides partial thermal conduction rather than a large thermal discontinuity, thereby decreasing the thermal contrast in the thermographic images. This sometimes occurs in bonded or laminated structures, where unbonded, partially bonded, or delaminated areas in the joint may appear completely bonded in the thermographic image sequence.

There is a need for a device and method that can detect a kissing unbond subsurface defect in a non-destructive manner via active thermographic techniques.

#### SUMMARY OF THE INVENTION

Accordingly, the present invention detects a kissing unbond-type subsurface defect in a specimen by changing the dimensions of the defect while or immediately after the part is heated. The specimen's surface temperature is monitored over time to detect the defect. More particularly, the invention includes an image generator, such as an infrared camera, and means for changing the pressure on a surface of the specimen being tested to stress and unstress the specimen. The pressure changes cause the walls of the kissing unbond defect to move relative to each other, separating and/or shifting the walls of the defect to create thermal discontinuities in the specimen and increase the thermal contrast between the defect and the surrounding material. The pressure changes can include applying a vacuum to generate a tensile force on the surface of the specimen, which displaces the specimen surface at areas containing kissing unbond defects, or applying acoustic, ultrasonic, or mechanical energy at selected time intervals to shift unbonded surface with respect to each other. As the degree of contact in the defect's walls is altered, sequential thermographic images of the sample are obtained over time as

heat flows through the specimen, revealing defects that may otherwise be undetectable by conventional means.

### BRIEF DESCRIPTION OF THE DRAWINGS

5            Figures 1A, 1B and 1C illustrate a kissing unbond defect and its corresponding temperature vs. time trace before and during application of a tensile force on a specimen's surface above the defect;

            Figure 2 illustrates a first embodiment of a kissing unbond defect detector according to the invention;

10           Figure 3 illustrates a second embodiment of the inventive kissing unbond defect detector;

            Figure 4 illustrates a third embodiment of the inventive kissing unbond defect detector; and

            Figures 5A and 5B illustrate a fourth embodiment of the inventive kissing unbond defect detector.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

            Figures 1A and 1B illustrate a kissing unbond defect 100 before and during application of a tensile force on a surface 102 of a specimen 104 to be tested. As  
20           explained above and as shown in Figure 1A, the walls of the kissing unbond defect 100 may allow partial transfer of heat across the defect 100, causing marginal thermal contrast with respect to the surrounding material and rendering the defect 100 virtually undetectable via conventional methods.

Figure 1B illustrates what happens to the kissing unbond defect 100 when tensile force is applied to the specimen surface 102 directly above the defect 100. If there is no defect in the area where the tensile force is applied, the tensile force causes little or no surface displacement. If, however, the tensile force is applied to the surface 102 directly  
 5 above a defect 100, as shown in Figure 1B, the force will create a noticeable surface displacement as the walls 106, 108 of the defect 100 separate or otherwise change in their degree of contact, creating an air gap or enclosed vacuum having different thermal characteristics than the surrounding material in the specimen 104.

To detect thermal contrasts in the specimen 104 indicating the presence of a defect  
 10 100, one embodiment of the invention includes comparing the temperature vs. time trace of each pixel in the image of an unstressed specimen with the temperature vs. time trace of each pixel in the image of a stressed specimen. Any differences in the two traces, indicating a change in the dynamic heat flow characteristic in the stressed specimen as the specimen 104 cools, indicates the presence of a sub-surface defect. An example of such a  
 15 comparison is illustrated in Figure 1C, which illustrates a noticeable change in the temperature vs. time trace of the stressed specimen as force is applied. In this example, the sub-surface defect causes the specimen 100 to cool noticeably faster in the defect area than the unstressed sample over time. If the defect did not exist, the traces for both the stressed and the unstressed specimens would have been the same.

20 Figure 2 illustrates one embodiment of the present invention. The apparatus shown in Figure 2 includes a sealed enclosure 200, a heater, such as flashlamps 202, and an infrared camera 204. The enclosure should be sealed in an airtight manner so it can hold air pressure variations in a constant, measurable way. Although the figure shows that the enclosure 200 has an opening 206, preferably gasketed, for accommodating a lens

208 on the camera 204, the enclosure 200 can also be constructed with a window through which the lens 208 and/or the flashlamps 202 can project onto the specimen 104. Note that it is preferable to place the flashlamps 202 within the enclosure 200 since it may be difficult to find window materials that pass both infrared and visible wavelengths at

5 acceptable levels for accurate monitoring. Possible window materials include zinc sulfide, zinc selenide, germanium, silicon, and any other material that is transparent in the wavelength band of the camera. The specific material chosen will depend on the infrared camera's 204 wavelength and the type of heater being used to heat the specimen. In short, the window material may be any material that is transparent in the wavelength band of the

10 camera, has sufficient rigidity to withstand vacuum pressure, has the ability to withstand thermal cycling, and resists discoloration over time.

The sealed enclosure 200 preferably has a skirt 210 made out of a flexible material, such as rubber or an elastomeric polymer, to form a vacuum seal on the surface 102 of the specimen 104. The skirt 210 may also include holes 211 leading to the interior

15 of the enclosure 200. A pump fitting 212 attached to the sealed enclosure 200 is connected to a pump (not shown) for increasing and decreasing the air pressure inside the enclosure 200.

To maintain the airtightness of the enclosure 200, all openings, such as the opening accommodating the infrared camera lens 208, should be sealed or fitted with

20 gaskets. The pump can vary the air pressure inside the enclosure 200 by pumping air into or pulling air out of the enclosure 200, thereby distorting the surface 102 of the specimen 104 and shifting the walls of the kissing unbond defect 100. To detect a kissing unbond defect, the flashlamps 202 heat the surface 102 of the specimen 104, and the pump varies



the pressure inside the enclosure 200 to vary the degree of contact between the walls 106, 108 of the kissing unbond defect 100, if one exists at the enclosure's 200 location.

The infrared camera 204 generates a series of thermographic images over time of the de-pressurized and/or pressurized images to capture information about the thermal energy flow through the specimen as the specimen 104 cools. As explained above with respect to Figures 1A and 1B, kissing unbond defects will tend to enlarge when the enclosure 200 is de-pressurized, thereby creating a thermal discontinuity, because the vacuum will distort the surface 102 above the defect 100 to a greater degree than the surface 102 of the material surrounding the defect 100. The thermographic image sequence generated by the camera 204 can be sent to a display monitor or computer (not shown) for further analysis, if desired. It is important to note that although the use of vacuum pressure is believed to be a preferred way to distort the surface 102, other techniques for distorting surface 102 are contemplated, such as physically loading the specimen (through tension, compression, shear, etc.) or vibrating the specimen (such as via ultrasonic means).

Figure 3 illustrates a variation of the apparatus explained above by including an infrared transparent window 300 inside the enclosure 200, dividing the enclosure 200 into a first section 302 and a second section 304. The window 300 must create an airtight separation between the first and second sections 302, 304 so that the second section 304 can maintain variances in its air pressure. As in the first embodiment, the camera 204 and flashlamps 202 can be arranged outside the enclosure 200, or alternatively the camera lens 208 and/or the flashlamps 202 can be disposed inside the first section 302 of the enclosure 200, as illustrated in Figure 3. The pump (not shown) is arranged to inject air into and/or withdraw air from only the second section 304 through the pump fitting 212,

without varying the air pressure in the first section 302. De-pressurizing the second section 304 will pull on the surface of the specimen and shift the walls of any kissing unbond defects 100 below the surface, causing thermal contrast that is detectable by the infrared camera 204. In this embodiment, because the pump has to inject and remove air only from the second section 304 rather than from the entire enclosure 200, pressure changes can be conducted more quickly and with a smaller pump due to the reduced volume of the second section 304.

The devices shown in Figures 2 and 3 are particularly appropriate for evaluating smaller specimens 104 because the enclosure 200 only has to be moved a few times to cover the entire surface area of the specimen 104. For specimens having a larger surface area, however, individually testing small sections of the specimen 104 can be time-consuming because the enclosure 200 must be repositioned and re-pumped at each new location when the infrared camera 204 generates the thermographic image sequence for the new location. Figure 4 illustrates another embodiment of the present invention where the pressure of the air surrounding the entire specimen 104 can be changed all at once rather than in individual small sections. The embodiment includes a sealed chamber 400 large enough to enclose the specimen 104. If the camera 204 and heater, such as a flashlamp 202, are both located inside the chamber 400, power cords and connectors can be run through gasketed ports (not shown) to the outside of the chamber 400 without compromising the airtightness of the chamber 400. Alternatively, as shown in Figure 4, the chamber can include a transparent window 402 so that either the camera 204 or the flashlamps 202, or both, can be located outside the chamber 400. As explained above, the window 402 material is selected based on the camera wavelength and on the type of heater used. In this embodiment, the pump (not shown) pressurizes and/or de-pressurizes

the entire chamber 400 via the pump fitting 212, thereby closing and/or opening all of the kissing unbond defects 100 in the specimen 104 at virtually the same time. Like the previously described embodiments, the flashlamps 202 heat the surface of the specimen before or during the pressure changes and the camera 204 generates active thermographic images to monitor the heat flow through the specimen 104. The specimen 104 and/or camera 204 can be repositioned to obtain thermographic image sequences for all surfaces of the specimen 104.

Yet another embodiment of the present invention is shown in Figures 5A and 5B.

In this embodiment, heat is preferably provided by at least one low-power lamp 602 that continuously directs heat to the specimen surface 102. As a result, the surface temperature of the specimen 104 rises at a steady state or in a slow monotonic fashion while the specimen 104 is in an unstressed state. When the specimen 104 reaches a steady state temperature, the thermal energy from the lamps 602 is dissipated through the specimen 104 at the same rate that the energy is being absorbed. Further, for a sufficiently thick specimen 104, the specimen 104 will cool generally via smooth conduction of thermal energy from the surface being heated to the cooler rear portion of the specimen 104. Applying an external force to the specimen 104 will disrupt this equilibrium around the kissing unbond defect 100 and thereby generate sufficient thermal contrast for the defect 100 to be thermographically detectable. As illustrated in Figure 5A, stressing the disbanded area can be conducted via ultrasound, acoustic, or mechanical energy through an attachment 604 coupled to the specimen's surface 102. Further, as can be seen in Figure 6B, applying the external force in a discrete, systematic manner over time will create noticeable discontinuities in the temperature vs. time trace of the specimen 104 as the external force creates subsurface pockets that interrupt the flow of

thermal energy through the specimen 104. The embodiment illustrated in Figures 5A and 5B is particularly suitable for inspecting coated metallic specimens, where the metallic specimen tends to be a better heat conductor than the coating. Any delaminations or weak bonding areas between the coating and the substrate tend to act as kissing unbond defects and can be stressed by the external force, making them detectable by the infrared camera 204.

Note that with all of the above disclosed embodiments, there are many ways and sequences in which to heat the specimen 104, vary the pressure on and around the specimen 104, and generate thermographic image sequences without departing from the scope of the invention. For example, the pump can generate a vacuum within the enclosure 200 or chamber 400, shifting the walls of any kissing unbond defects 100, before or during heating while the camera 204 generates a thermographic image sequence as the specimen 104 heats and cools. Alternatively, the kissing unbond defects 100 can be alternately stressed and unstressed by varying the pressure inside the enclosure 200 or chamber 400 or by starting and stopping force application and comparing the active thermographic images of the stressed specimen and the unstressed specimen. Thus, the invention can effectively detect kissing unbond defects 100 that would ordinarily go undetected by conventional active thermographic methods simply by displacing the surface 102 above the defect 100 to increase the thermal contrast between the defect 100 and the surrounding material. Further, the heat input can also be varied and sent in the form of a pulse, a step, modulated or continuously applied. The specific sequence in which the heating, stress application, and image generating steps are conducted does not matter in the invention as long as the stress changes at least one dimension of the kissing unbond defect to render it visible via active thermographic methods.

The manner in which the stressed image and the unstressed image are evaluated can be selected from various methods. Calculating/viewing the difference between the sums of the stressed images and the unstressed images is one way to compare the two images. Alternatively, histograms of the stressed and unstressed images can be compared, such as according to the method described in co-pending patent application Serial No. 08/608,901 entitled "Method of Interpreting Thermographic Data For Non-Destructive Evaluation," incorporated herein by reference. Other methods include applying of a mathematical correlation function to correlate the two sets of images, viewing an image displaying the ratio between the stresses and unstressed images, and visually comparing the stressed and unstressed images without conducting additional calculations.

The application and removal of stress on the specimen can be repeated several times during a single heating cycle. Alternatively, separate heating cycles can be conducted when generating the stressed and unstressed images. Note that regardless of the specific method and device used to stress/unstress the specimen and monitor heat flow through the specimen, the methods and devices will reveal only kissing unbond defects because other defects that are detectable via conventional active thermographic methods will appear identical in the stressed and unstressed images and will therefore cancel each other out when the two images are compared.

It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that the method and apparatus within the scope of these claims and their equivalents be covered thereby.

## CLAIMS

## WHAT IS CLAIMED IS:

1. A method for non-destructive evaluation of a specimen, comprising the  
5 steps of:
- directing heat onto the specimen;
- applying a force onto a surface of the specimen; and
- generating an infrared image to detect the presence of a subsurface defect,  
wherein the application of the force onto the surface of the specimen exacerbates a  
10 thermal discontinuity proximate to the subsurface defect.
2. The method of claim 1, wherein the applying step includes decreasing air  
pressure in a vicinity of the specimen to change the at least one dimension of the  
subsurface defect.  
15
3. The method of claim 1, wherein the applying step includes disturbing the  
specimen using ultrasonic, acoustic or mechanical energy.
4. The method of claim 1, wherein the applying step includes:  
20 placing the specimen in a chamber; and
- generating a vacuum in the chamber to change at least one dimension of the  
subsurface defect.
5. The method of claim 1, wherein the applying step includes:

placing a sealed enclosure on the surface of the specimen; and  
generating a vacuum in the sealed enclosure to change the at least one dimension of the subsurface defect.

5           6.       The method of claim 5, wherein the sealed enclosure is divided into two sections such that the vacuum generated in said generating step produces a vacuum in one of the two sections.

10           7.       The method of claim 1, wherein said applying step includes increasing and decreasing the pressure on the specimen surface, wherein said generating step includes generating a first thermographic image when the pressure is increased and generating a second thermographic image when the pressure is decreased, and wherein the method further comprises the step of comparing the first and second active thermographic images to detect the subsurface defect.

15           8.       The method of claim 7, wherein the generating step generates a plurality of first thermographic images and a plurality of second thermographic images over time, and wherein the comparing step is conducted by calculating the difference of the sums of the first thermographic images and the second thermographic images.

20           9.       The method of claim 7, wherein the generating step generates a plurality of first thermographic images and a plurality of second thermographic images over time, and wherein the comparing step includes generating histograms corresponding to the plurality of first and second thermographic images and comparing the histograms for the plurality

of first thermographic images with the histograms for the plurality of second thermographic images.

10. The method of claim 7, wherein the generating step generates a plurality of first thermographic images and a plurality of second thermographic images over time, and wherein the comparing step includes mathematically correlating the plurality of first thermographic images with the plurality of second thermographic images.

11. The method of claim 7, wherein the generating step generates a plurality of first thermographic images and a plurality of second thermographic images over time, and wherein the comparing step includes viewing an image corresponding to the ratio between the plurality of the first thermographic images and the plurality of the second thermographic images.

12. The method of claim 7, wherein the generating step generates a plurality of first thermographic images and a plurality of second thermographic images over time, and wherein the comparing step includes visually comparing the plurality of first thermographic images and the plurality of second thermographic images.

13. The method of claim 7, wherein the applying step includes placing the specimen in a chamber before said generating step.

14. The method of claim 7, wherein the applying step includes placing a sealed enclosure on the specimen surface before said generating step.



15. A method for non-destructive evaluation of a specimen, comprising the steps of:

directing heat onto the specimen;

5 placing a sealed enclosure on the specimen surface;

applying a vacuum to at least a portion of a surface of the specimen by decreasing the air pressure in the sealed enclosure; and

generating an infrared image to detect the presence of a subsurface defect, wherein the vacuum from the applying step enlarges at least one dimension of the  
10 subsurface defect to create a thermal discontinuity.

16. The method of claim 15, wherein the sealed enclosure is divided into two sections such that the vacuum generated in said applying step produces a vacuum in one of the two sections.

15 17. The method of claim 15, wherein said applying step further includes the step of increasing the air pressure in the sealed enclosure, wherein said generating step includes generating a first active thermographic image when the pressure is increased and generating a second active thermographic image when the pressure is decreased, and  
20 wherein the method further comprises the step of comparing the first and second active thermographic images to detect the subsurface defect.

18. An apparatus for non-destructive evaluation of a specimen, comprising:  
a heat-sensitive image generator that generates thermographic images;

a heater that increases the temperature of the specimen; and  
means for applying a force to a surface of the specimen, wherein the applying  
means changes at least one dimension of a subsurface defect in the specimen to create a  
thermal discontinuity.

5

19. The apparatus of claim 18, wherein said heater is at least one flashlamp  
that directs heat to the specimen surface.

10

20. The apparatus of claim 18, wherein said distorting means includes:  
a sealed enclosure that is placed on the specimen's surface; and  
a vacuum pump that generates a vacuum inside the sealed enclosure.

15

21. The apparatus of claim 20, wherein the sealed enclosure is divided into  
two sections, and wherein the vacuum pump generates the vacuum inside the sealed  
enclosure in one of the two sections.

22. The apparatus of claim 20, wherein the heater is a flashlamp disposed  
inside the sealed enclosure to direct light to the specimen surface.

20

23. The apparatus of claim 18, wherein said distorting means includes:  
a chamber for holding the specimen; and  
a vacuum pump that generates a vacuum inside the chamber.

24. The apparatus of claim 23, wherein the chamber includes a window, wherein the heater is a flashlamp located outside the chamber and directs light through the window to heat the specimen, and wherein at least part of the image generator is located outside the chamber.

5

25. The apparatus of claim 23, wherein the chamber includes a window, wherein the heater is a flashlamp located inside the chamber and directs light on the specimen to heat the specimen, and wherein at least part of the image generator is located outside the chamber.

10

26. The apparatus of claim 23, wherein at least one of the heater and the image generator are located inside the chamber.

15

27. The apparatus of claim 18, wherein said heater is a lamp that continuously directs heat to the specimen, and wherein said applying means includes an attachment that couples to the surface of the specimen to apply the force.

28. The apparatus of claim 27, wherein said attachment provides the force via ultrasonic, acoustic, or mechanical energy.

**METHOD AND APPARATUS FOR  
DETECTING KISSING UNBOND DEFECTS**

ABSTRACT OF THE DISCLOSURE

5           A active thermographic method for detecting subsurface defects in a specimen,  
particularly kissing unbond defects, includes heating a specimen, applying a force to the  
surface of the specimen to shift and separate the walls of the defect, and obtaining  
thermographic images of the specimen over time to monitor the heat flow through the  
specimen and detect thermal discontinuities. Because kissing unbond defects normally  
10   have good physical contact, and therefore good thermal conductivity, between its walls,  
these defects can go undetected in conventional active thermographic methods. By  
distorting the surface of the specimen, the kissing unbond defect is enlarged enough to  
generate sufficient thermal contrast for the defect to appear in the thermographic images.

15   R0062943

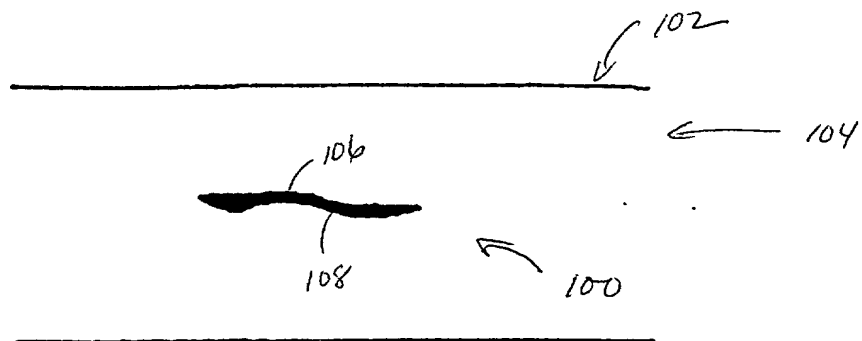


FIG. 1A

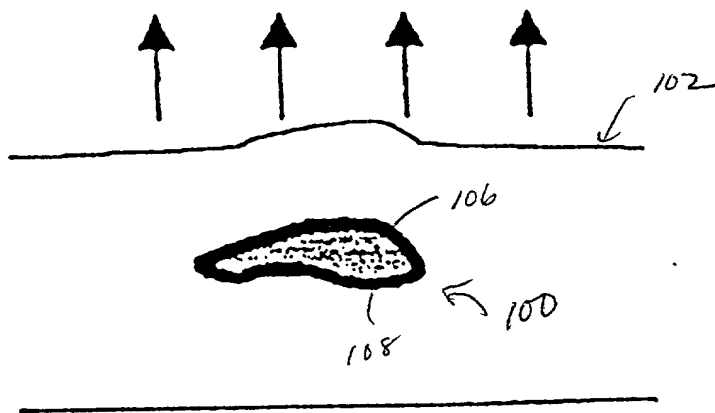


FIG. 1B

Temperature

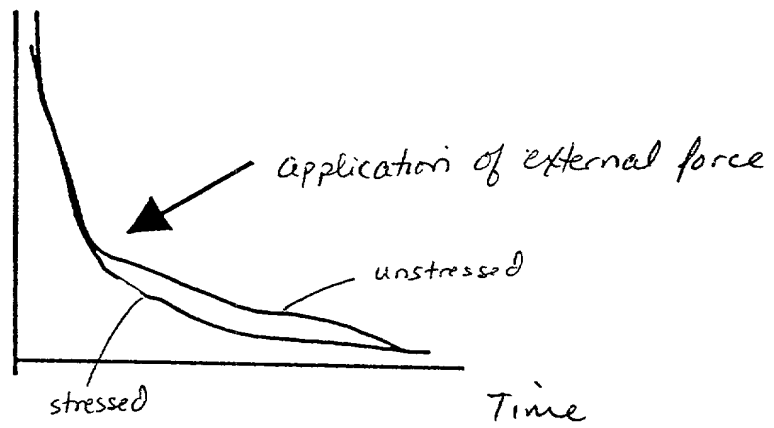


FIG 1C

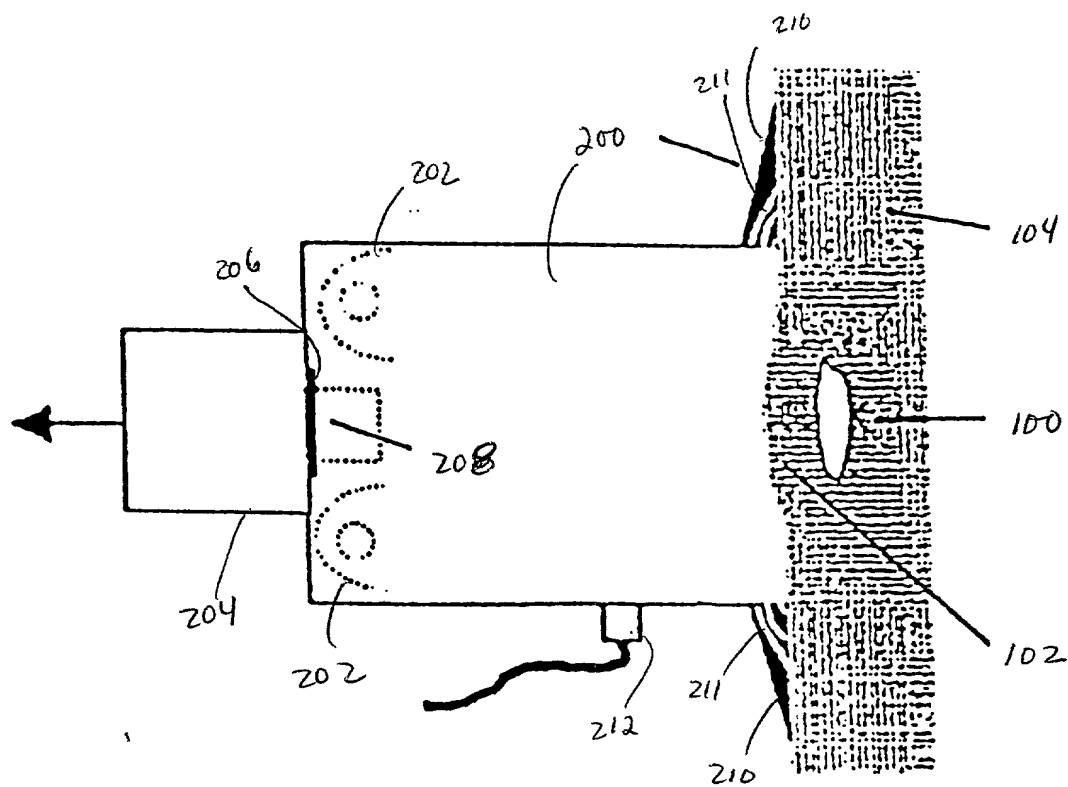


FIG. 2



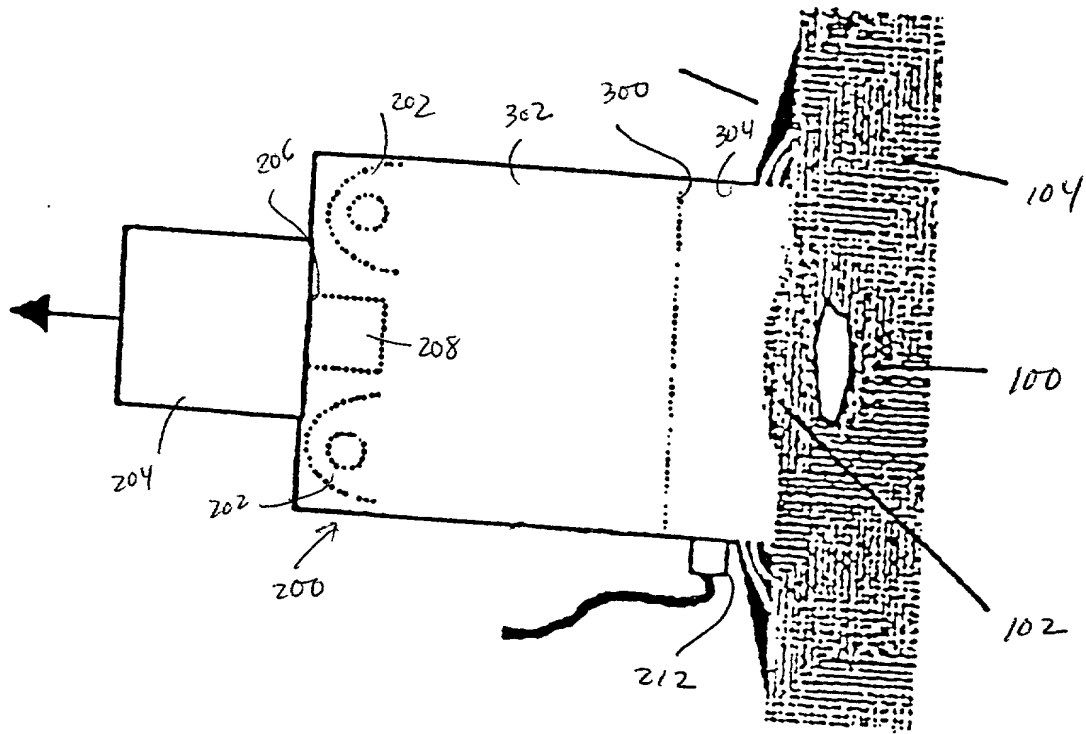


FIG. 3

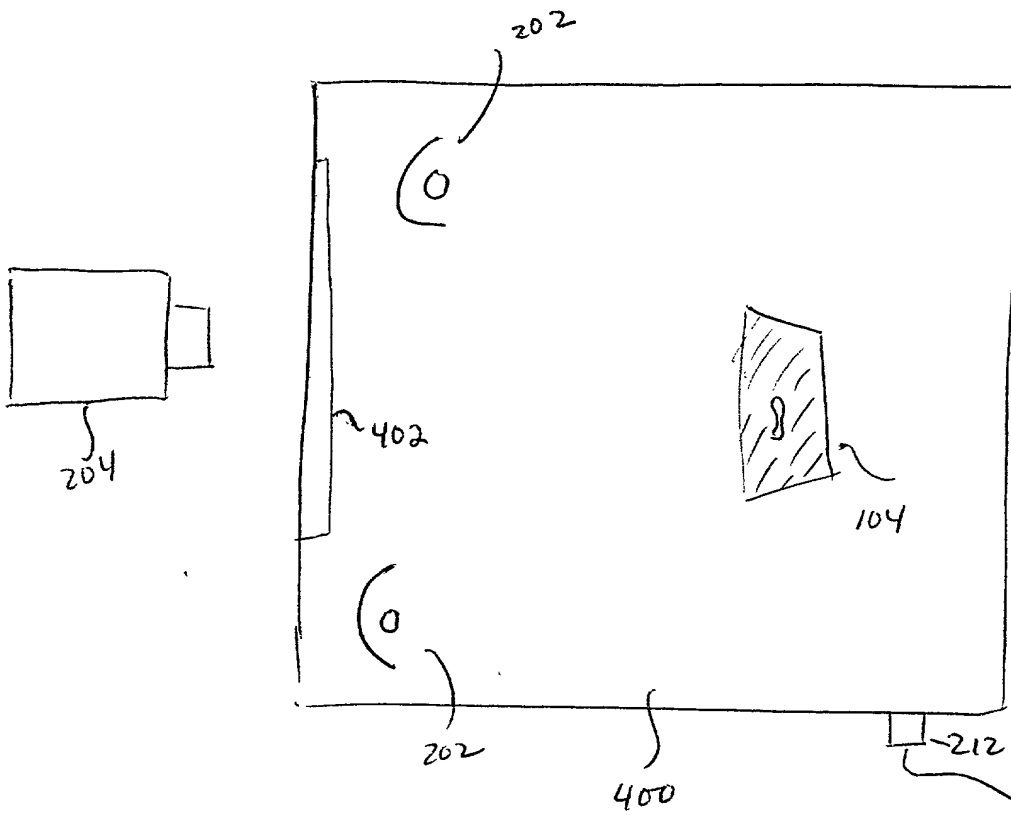


Fig. 4

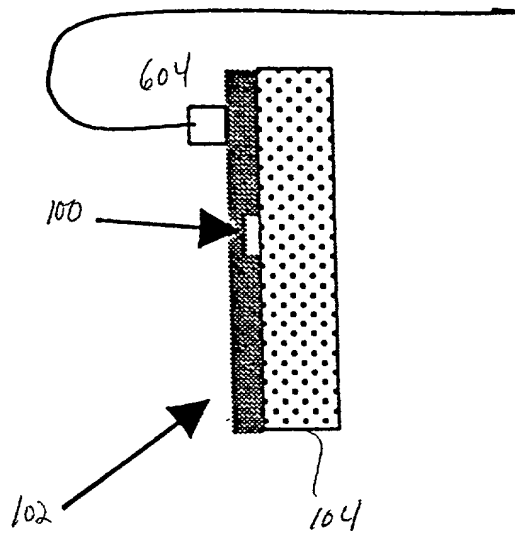
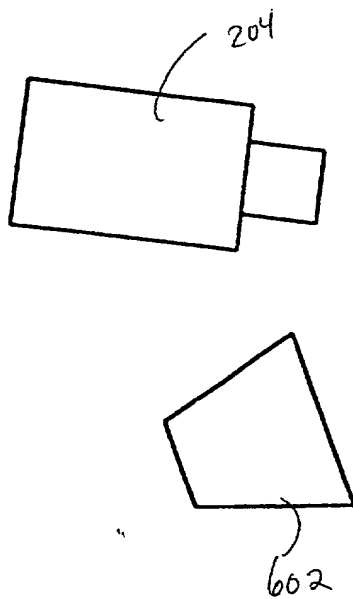


FIG. 5A

FIG. 5B

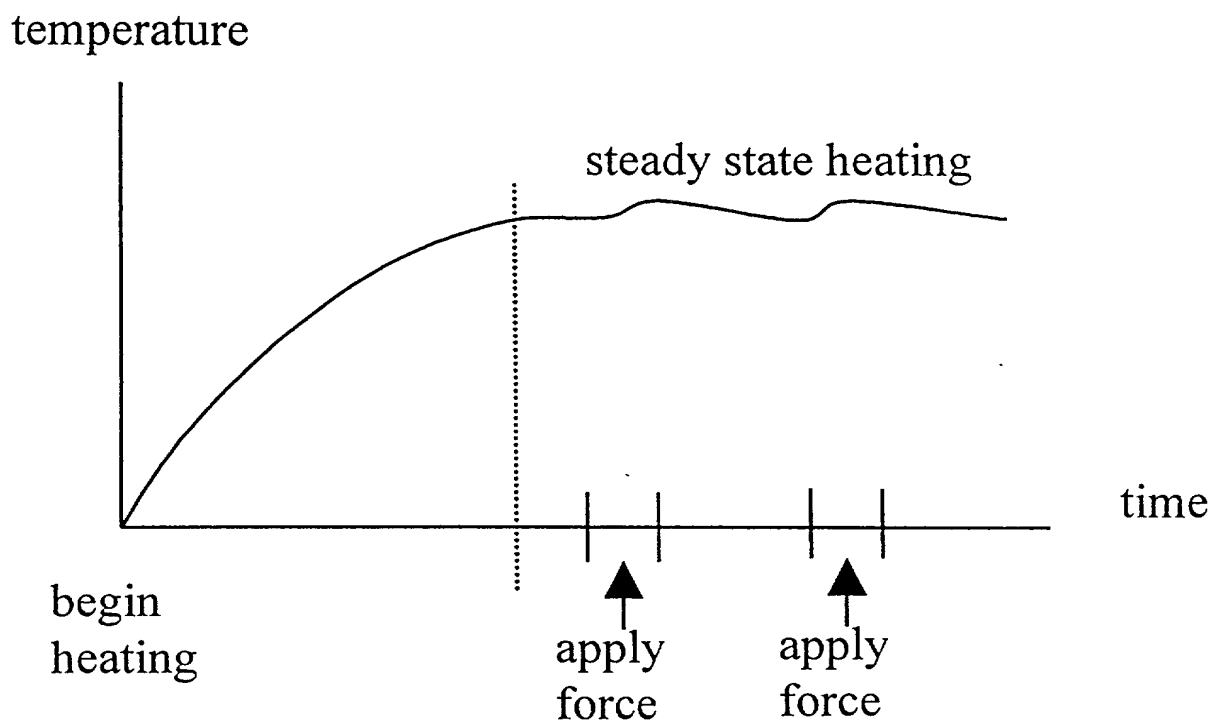


FIG. 5B